FACTSHEET

AGRICULTURAL ENGINEERING

ORDER NO. 06-057

JUNE 2006

AGDEX 717

Ontario Ministry of Agriculture, Food and Rural Affairs

Energy Opportunities

ENERGY-EFFICIENT MECHANICAL VENTILATION FAN SYSTEMS

S. Clarke and D. Ward

INTRODUCTION

A large percentage of livestock buildings are ventilated using mechanical fan systems. Since these systems operate year round, they consume a considerable amount of energy. Most farm operations can save energy and money by making some changes to their system.

To achieve these savings, consider the following when selecting or upgrading a ventilation system for a farm operation:

- proper sizing of each fan
- energy efficiency of each fan
- proper maintenance of the entire ventilation system

All buildings ventilated by exhaust fans (see Figure 1, right) operate on the principle that fans create a partial vacuum within the building as they expel air outside. This vacuum causes fresh air to be drawn into the building. The pressure difference between the inside and the outside of the building is called *static pressure*. Static pressure indicates the resistance that fans must overcome to actually move air through the building. Static pressure is usually measured in millimetres (inches) of water column (W.C.) or water gauge. Most ventilation systems for farm buildings are designed to operate at a static pressure of 2.5–3.0 mm (0.10–0.125 in.) water gauge.

In livestock buildings ventilated by fans, the quantity of fans should be enough to provide at least four stages or levels of ventilation between the winter minimum ventilation rate for humidity control (Stage 1) and the summer maximum ventilation rate for temperature control (Stage 4).

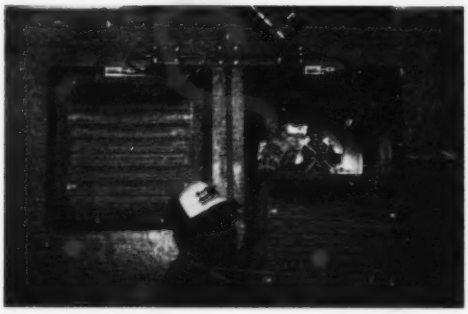

Figure 1. Typical exhaust fan installation in livestock barn. Newer fans have plastic blades designed for maximum airflow. (Source: Agviro)

When selecting ventilation fans:

- Size the fans to meet the actual air movement requirements at the static pressures that will be expected in the room or building.
- Choose the proper equipment for the job (i.e., pit fan, wall fan, with or without shutters, wind protection, etc.).
- Choose energy-efficient equipment.
- Choose reliable products.
- Buy equipment from manufacturers and suppliers with a good reputation.
- Choose the best price for the right equipment.

Controls are an essential component of the ventilation system. A wide variety of electronic controllers is available.

Electronic controllers have a number of benefits:

- The ventilation system is continuously being managed.
- Users have the ability to control temperatures more precisely.

- The heating and ventilation systems can be interlocked to avoid wasting energy.
- More energy-efficient equipment can be used, which can be properly sequenced for optimum operation.
- Livestock performance can be improved.

SELECTING AND MAINTAINING FANS

Sizing

Sizing of fans is very important. Oversized fans waste energy and cannot control the room temperature effectively since they cycle on and off constantly. Undersized fans also have difficulty controlling room temperature and will not provide the necessary airflow.

Fan Efficiency

The term "fan efficiency," or "energy use efficiency," is used loosely in the ventilating fan industry to describe a number of fan performance criteria.

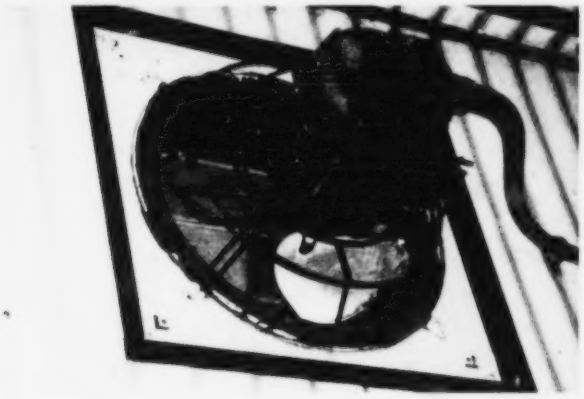

Figure 2. Older style exhaust fan with elephant ear blades. Note fan name plate on the back of the motor.

A name plate rating is located on all motors (see Figure 2, above). It states the amperage and voltage (among other items) that occur during steady-state conditions (once the motor is running, not just when it is starting up). Consider the following about amperage and voltage:

- Do not use amperage to compare fan efficiency — many other factors also affect performance.
- Wherever possible, use 240-volt (not 120-V) motors to increase the efficiency of energy use. Higher voltages will decrease the energy that is lost in the wire itself.
- All wiring should be minimum #12 gauge, to reduce line losses.

Another rating is horsepower (HP). This refers to power at the shaft, again, at steady-state conditions. This number is not reliable for comparing fan efficiencies.

So, what should be used to compare various fans for efficiency of energy use?

The only method to use is CFM/W (cubic feet of air per minute per watt) or, in metric units, L/s/W (litres per second per watt). So when different fans are compared, all that needs to be considered is (1) how much air can be moved and (2) how much energy is required to move it.

Considerations when selecting a fan based on L/s/W or CFM/W

- **Independent Testing.** The L/s/W or CFM/W ratings should be provided by an independent test laboratory such as the University of Illinois Bioenvironmental and Structural Systems (BESS) Laboratory (http://www.bess.uiuc.edu) or the Air Moving and Conditioning Association (AMCA) (see Figure 3, below). The BESS lab tests a large number of commercially available agricultural fans each year. Results of tests for performance and efficiency are shown on their website and in a book that is published each year. Other independent labs may conduct tests as well. However, before relying on the data from these labs, consider whether their results are truly impartial and of good quality.

Figure 3. University of Illinois BESS label (logo) that appears on all fan performance data released by this laboratory each year.

- **Static Pressure Ratings.** The L/s/W or CFM/W ratings should be provided for various static pressure ratings, usually from 0–6.5 mm (0–0.25 in.) of water column in 1.25-mm (0.05-in.) increments. Compare all fans at the same static pressure, usually 2.5 mm (0.10 in.). The higher the L/s/W or CFM/W value, the more efficient the fan is. Figure 4, next page shows the recommended minimum fan efficiencies for 600-mm (24-in.), 900-mm (36-in.) and 1,200-mm (48-in.) fans.

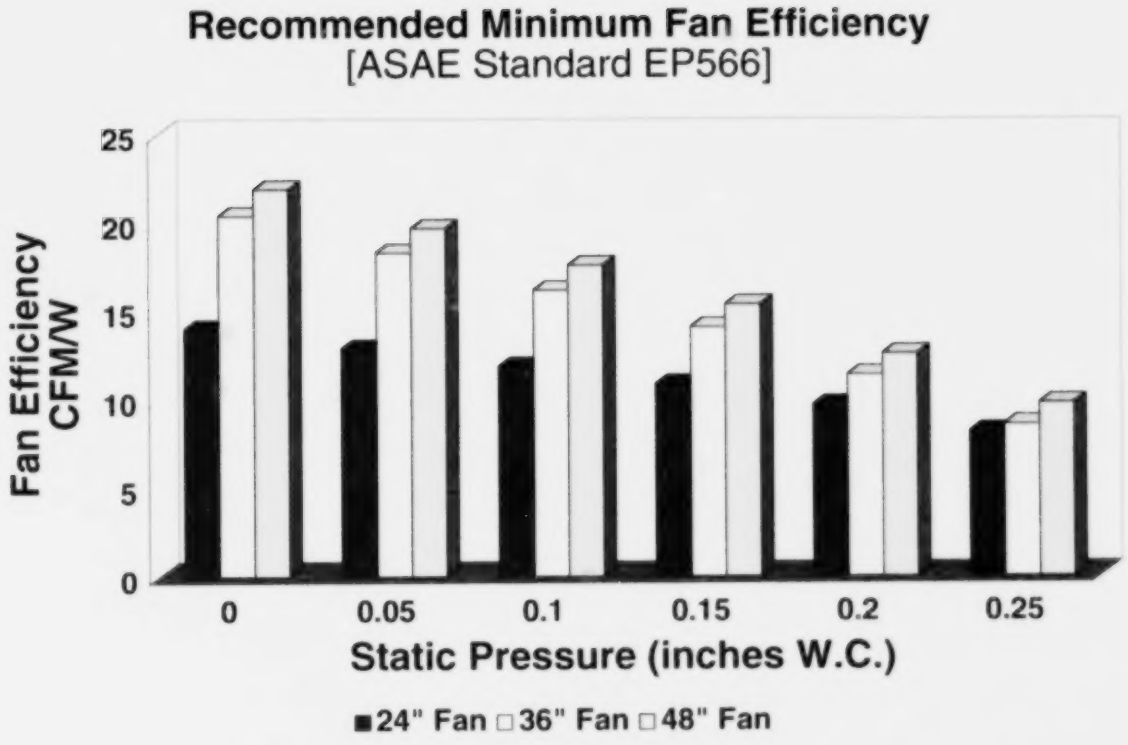

Figure 4. American Society of Agricultural Engineering (ASAE) fan efficiency standard for several of the common sizes of fans seen in agricultural buildings.

- **Airflow in Windy Conditions.** Check to see if the airflow (cubic feet of air per minute, or CFM) number falls quickly as static pressure increases. If it does, the fan will perform poorly against the effect of wind pressure.

> For example, an energy-efficient minimum ventilation rate or first-stage fan producing 1,416 L/s at 2.5 mm (3,000 CFM at 0.1 in.) and only 472 L/s at 6.5 mm (1,000 CFM at 0.25 in.) would be a poor choice of fan in windy locations. A less efficient fan may provide 1,416 L/s at 2.5 mm (3,000 CFM at 0.1 in.) and 850 L/s at 6.5 mm (1,800 CFM at 0.25 in.). This fan would be far more reliable in windy locations.

Figure 5, next page, top, shows two 600-mm (24-in.) fans. Fan A not only moves more air, but maintains a more stable performance curve (its output drops only 23% from 3,999 L/s to 2,596 L/s as static pressure increases to 7.6 mm (7,200 CFM to 5,500 CFM as static pressure increases to 0.30 in.). Fan B would be a poor choice, especially in windy conditions. 't moves less air (2,313 L/s (4,900 CFM)) and drops dramatically in output (73% to 614 L/s (1,300 CFM) as static pressure increases to 7.6 mm (0.30 in.)).

Figure 6, next page, bottom, shows how the fan efficiency for both fans decreases as static pressure increases. The decrease is less for fan A. The important information from the two graphs is that diameter is not an indication of the fan output capacity or fan efficiency. One energy-efficient fan may not be stable or may not offer consistent energy efficiency over a wide static pressure range compared to another energy-efficient fan.

Size fans first to match the various ventilation stages required. Subsequent stages beyond the Stage 1 and 2 fans (single speed) can and should be more energy efficient as they are not as critical and usually are not operated as variable speed. If the building is located in an area of high prevailing winds (and thus pressure on the fans is high), install windbreaks or wind hoods to ensure optimum airflow.

Use one large belt-driven fan instead of several small direct-drive fans to reduce energy use, initial capital investment and maintenance costs. Direct-drive fans should achieve an efficiency of 10 CFM/W, whereas belt-driven fans should achieve closer to 20 CFM/W.

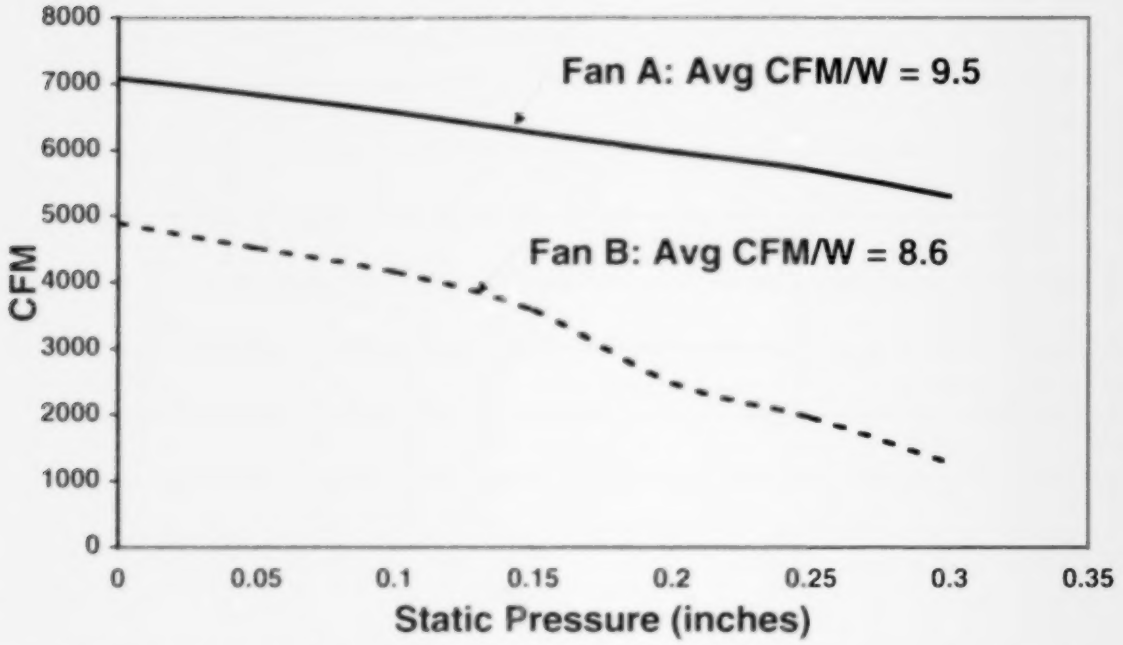

Figure 5. Fan performance curves for two 600-mm (24-in.) fans comparing airflow (CFM) vs static pressure (inches of water column).

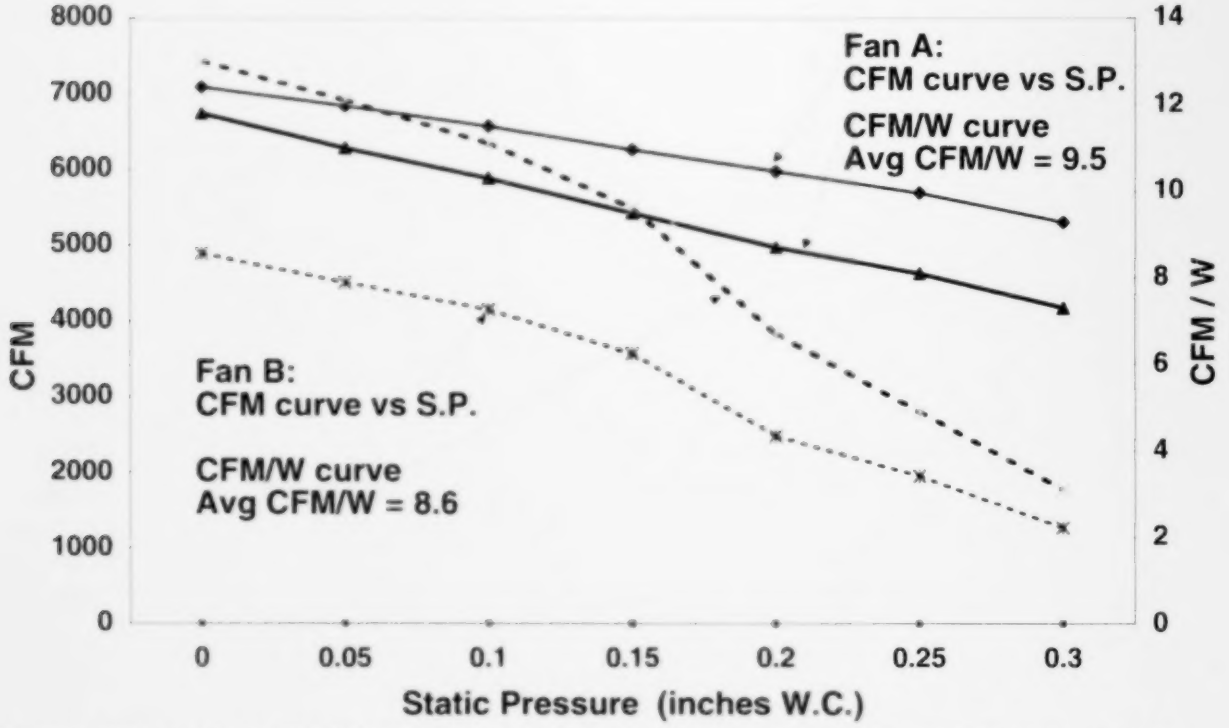

Figure 6. CFM vs. S.P. and CFM/W vs. S.P. Fan performance curves for same two 600-mm (24-in) fans comparing airflow (CFM) vs. static pressure (inches). Fan efficiency curve (CFM/W) vs. static pressure (inches) for both fans.

Maintenance

Check fans regularly to ensure that they are properly maintained. For example, ensure the belts in belt-driven fans are properly tightened — too loose and the fan output will drop, too tight and bearings may fail prematurely. A poorly adjusted belt can result in a 30% reduction in airflow. Clean fan blades and louvres regularly to improve the efficiency of the ventilation system. Dirt and dust accumulation can greatly reduce airflow and insulate the motor, causing overheating.

CALCULATING SAVINGS IN OPERATING COST FROM USING ENERGY-EFFICIENT VENTILATION FANS

When choosing between two or more fans to accomplish the same ventilation job, consider the economics of each alternative. The total cost of ventilation fans includes initial cost, interest on investment, and maintenance and operating costs. Operating costs are affected by energy use and cost as well as the overall fan efficiency. The following equation can be used to calculate the annual Electrical Operating Cost Savings (EOCS) when comparing two different ventilation fans.

$$EOCS = \left(\frac{AFR_1}{FE_1} - \frac{AFR_2}{FE_2} \right) \times AOH \times ER \times 0.001$$

Where:

EOCS = Electrical Operating Cost Savings per year (in dollars/yr) when one fan is used compared to another.

AFR_1 = Airflow Rate (L/s or CFM) of Fan #1, the fan with the lower efficiency, at the selected static pressure.

FE_1 = Fan Efficiency (L/s/W or CFM/W) of Fan #1, the fan with the lower efficiency, at the selected static pressure.

AFR_2 = Airflow Rate (L/s or CFM) of Fan #2, the fan with the higher efficiency, at the selected static pressure.

FE_2 = Fan Efficiency (L/s/W or CFM/W) of Fan #2, the fan with the higher efficiency, at the selected static pressure.

AOH = Average Operating Hours per year (h/yr) for the fan.

ER = Electrical Rate (dollars/kW-h) charged by the electrical supplier.

Example:

From the graph in Figure 5, an analysis can be done (Table 1) to determine what savings can be made by using the more stable Fan A. The analysis will be done at a static pressure of 5 mm (0.20 in.) of water column and assuming continuous operation all year (8,760 h/yr).

TABLE 1. Data for Analysis of Electrical Operating Cost Savings (EOCS)

$AFR_{1\,(Fan\ B)}$	$FE_{1(Fan\ B)}$	$AFR_{2(Fan\ A)}$	$FE_{2(Fan\ A)}$	AOH	ER
2480	6.7	5970	8.7	8760	$0.10/kW-h

Using the equation:

$$EOCS = \left(\frac{AFR_1}{FE_1} - \frac{AFR_2}{FE_2} \right) \times AOH \times ER \times 0.001$$

$$EOCS = \left(\frac{2,480}{6.7} - \frac{5,970}{8.7} \right) \times 8,760 \times \$0.10 \times 0.001$$

$$EOCS = -\$276.86$$

Therefore, the more energy-efficient fan saves up to $276.86/yr at a hydro rate of 10 cents per kW-h and at a static pressure of 5 mm (0.20 in.). Although this static pressure may be higher than actual for part of the year, the fan stability and increased output will decrease capital and operating costs over the lifetime of the fan.

SUMMARY

Investigating an energy-efficient fan system will pay off for years to come. Be sure to consider the energy efficiency of the ventilation system when designing renovations or purchasing new facilities.

This Factsheet was authored by Steve Clarke, P.Eng., Energy and Crop Systems Engineer, OMAFRA, Kemptville, and Dan Ward, P.Eng., Environmental Policy and Programs Branch, OMAFRA, Stratford. It was reviewed by Elin Gwyn, Marketing and Communications Officer, Environmental Policy and Programs Branch, OMAFRA, Guelph.

This Factsheet was developed with sponsorship from Hydro One and in partnership with the Ontario Power Authority, the Ontario Federation of Agriculture, the Ministry of Energy and the Ministry of Agriculture, Food and Rural Affairs.

Conservation Bureau
The power of conservation

hydro one

OFA Ontario Federation of Agriculture

FOR YOUR NOTES

FOR YOUR NOTES

Agricultural Information Contact Centre
1-877-424-1300
ag.info@omafra.gov.on.ca

www.omafra.gov.on.ca

POD
ISSN 1198-712X
Également disponible en français
(commande n° 06-058)

Ontario